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ERRATA

Vol. 7, No. 10, page 306 the formula $\dfrac{\mathrm{CMI}\left(\mathrm{L} - \frac{\mathrm{G}}{10}\right) + \mathrm{P}\left(15\mathrm{P} - \frac{\mathrm{G}}{10}\right)}{2}$ *should read*

$$\mathrm{CMI} = \frac{\left(\mathrm{L} - \frac{\mathrm{G}}{10}\right) + \left(15\mathrm{P} - \frac{\mathrm{G}}{10}\right)}{2}$$

Vol. 7, No. 10, page 308, 2nd article, col. 1, line 12: Schultz *should read* Schlutz

NUTRITION REVIEWS

VOL. 7 DECEMBER, 1949 No. 12

THE SOIL FACTOR IN HUMAN NUTRITIONAL PROBLEMS

About one hundred years ago, Chatin suggested an inverse relationship between the iodine content of soil and water and the occurrence of goiter in man. Possibly Chatin's observations were not based on fact—no evidence is presented in support of the suggestion—nevertheless, they are supported today by the experience of many workers in different parts of the world.

It is of more than passing interest that during the intervening years, practically no other direct relationships of importance have been established between deficiencies of minerals in the soil and human nutritional troubles resulting from these deficiencies in food, although speculation has been and is rife. The reason for this lies obviously in the almost insurmountable complications attendant upon long-time experiments with human subjects. Isolated communities dependent upon their own produce might be the answer. However, in the United States few such communities are available for study, and it has not been possible to separate economic and other circumstances from soil conditions as causes of poor nutrition in such communities.

Any sensible approach to the problem of soils in relation to human nutrition must therefore be indirect. Investigations of soils in relation to plant nutrition and in relation to animal nutrition are much less complex and the knowledge gained may be very useful in terms of human nutrition. Thus, if we can learn how to increase the nutritional quality of plants as grown for food we will have contributed to better human nutrition. If we can produce greater numbers of more healthy and productive animals through soil improvement programs, we will have again contributed to a higher level of human nutrition. For example, there are many areas where the maintenance of a family cow has not been practical because of a deficiency of cobalt or possibly copper and phosphorus in the soil. There are few contributions that will equal the correction of this trouble in raising the standard of living of farm families.

Well-defined distribution patterns of a number of human diseases have long been recognized by public health authorities. These patterns invite speculation as to their possible relationship to soil characters particularly when variations in these seem to bear some relationship to the geographic distribution of diseases. However, any inference that relationships of this kind are real and do exist has seldom been warranted on the basis of facts. For example, it is well known that the calcium content of the soil varies significantly from one soil to another as well as from one region to another. Local variations in calcium are generally due to differences in the soil parent material. Regional variations are more likely to be due to differences in climate and vegetation. Thus, as one goes from Florida to the northwest there is found to be a gradual increase in the calcium content of the soil that is correlated inversely with rainfall. There is evidence that this difference in calcium content is also reflected in the calcium content of the vegetation. However, before it is inferred that this causes troubles in man, it must be established that differences of the magnitude and kind found in the food produced on these soils are of importance in human nutrition.

In contrast to the rather small over-all differences across the country there are relatively large local differences found in the calcium content of vegetation. These differences are not always related to the total calcium content of the soil. In fact, any rational addition of calcium compounds to the soil, in some cases, has failed to change materially the calcium absorbed by the plant. We thus arrive at a general principle often observed in soil-plant studies that the composition of a plant is influenced to a greater degree by soil type (the lowest category of soil classification) than by fertilization of that soil. Soil type in this sense includes, of course, factors such as chemical composition, microorganisms, and physical structure as well as climatic factors.

These local differences in soil are of utmost importance in animal nutrition. Soil deficiencies that cause troubles in animals are not confined to any one section of the United States although they may occur more frequently along the Atlantic Coastal Plain or the Northeast than they do in the Middle West. If man obtained his food from one soil only these local differences in soils might be responsible for the occurrence of nutritional troubles in man. As a first approximation such a supposition seems more reasonable than one assuming important regional differences in food composition.

This is illustrated by a study of the minor elements in native forages of the North Carolina Coastal Plain region which revealed striking variations in the cobalt content in every section. Thus, in all parts of the Coastal Plain there are soils supplying little or no cobalt, while other soils are supplying ample amounts to the vegetation. In general, fewer cobalt-deficient soils were found in the older sections near the Piedmont than in the younger sections near the coast. The variability is so great, however, and the quantities of cobalt are so small that no significant trend of this kind can be established. The region as a whole cannot be classified as cobalt deficient, although individual soil types can be so classified.

The distribution patterns of some other minor elements such as copper, iron, and manganese in this Coastal Plain area were more definite. In fact for iron and manganese, highly significant trends were found. In general it was concluded that the older Coastal Plain soils were better than were the younger soils. However, only the area adjacent to the ocean, the lowest marine terraces, can be classified as bordering on deficiency in certain of these elements.

This finding is contrary to the popular conception of the relationship between the mineral content of plants and the age (in terms of use) of a soil. Much has been spoken and written about impoverished soils, leached soils, eroded soils, and otherwise "worn-out" soils and the occurrence of nutritional troubles in man. The truth of this cannot be denied (although confirmation is obviously difficult if not impossible) but the fallacy of the claims lies in the generalizations that have been made. Soils that have been used for a relatively short time under one set of conditions might be classified as "worn-out" although it is questionable whether soil scientists would so speak of them. Under another set of conditions soils could be used for thousands of years and still retain a high level of fertility. Furthermore, it is generally recognized that in a region such as the Atlantic Coastal Plain, the soils never had a phosphorus content sufficient to support an agricultural program including cattle.

An example of a real effect of agriculture on soil is found in many parts of the Coastal Plain where high applications of phosphorus have been used for many years. On some of these soils little or no response to phosphorus is now being obtained because of the accumulation of this element over the years. Of course, a part of this lack of response is due to the fact that other elements have become limiting in relation to the phosphorus. The point is, however, that fertilization can gradually improve poorer soils and maintain the better soils. It is also often overlooked by those speculating about the deterioration of our soils that the soil is a dynamic system. It is continually replenishing its supply of minerals from an almost inexhaustible source, the parent rock. Normal erosion is continually removing the depleted surface layer. Decomposition of rock is continually deepening the soil profile. The soil, therefore, is not a bank that requires an equal deposit of fertilizer for each unit of nutrient element that is removed. It is only when the nutrients are utilized faster than nature can supply them that fertilizers are needed. Probably in no case do all the elements removed have to be replaced by man.

Fertilizer practices have engendered controversial ideas in two respects. First, does any nutritional benefit other than an improved mineral content of the plant accrue as a result of fertilization? The evidence for a change in the amino acid composition of the plant protein as a result of fertilization that has been presented in the literature is not very convincing. The possibility that such changes occur cannot as yet be denied. In some carefully controlled forage experiments using sheep as a means of assaying such changes it was found that soil fertilization with superphosphate was not reflected in any improvement in the growth and health of the sheep that could not be accounted for by the greater phosphate content of the plant. On the other hand, when these forages were fed to rabbits, those from the high phosphate plots produced somewhat better growth in the rabbits that could not be accounted for by the difference in phosphorus intake. Obviously, here is a field of research that will require many years of painstaking effort. The immediate practicability of such work is open to question, but this does not necessarily diminish its importance to nutritional problems.

The second controversy of recent interest is the attack on commercial or "chemical" fertilizers by proponents of organic fertilizers. As in other appeals made to popular prejudice little, if any, real evidence is offered to support the contention that commercial fertilizers result in nutritional troubles of any kind in man. Here again, it is difficult to obtain the truth. In the design of experiments to test the relative values of inorganic and organic fertilizers on nutritional value in plants one is confronted with such problems as differences in the rate in which the fertilizer elements become available from the two kinds of material. Thus nitrogen and phosphorus may be released very slowly from a compost. This results in differences in the growth and maturity of the plants at any particular time. The vitamin content will thus be different whether the plants are harvested on the same day or at the same stage of maturity on different dates. Comparisons of this kind are not valid with respect to the effect of any particular source of the fertilizer elements. There is, in fact, some question as to whether valid comparative experiments can be set up to measure the effects of such different materials as composts and inorganic compounds on nutritional value in plants.

In general, the results obtained so far do not indicate any important differences in the vitamin content of vegetables grown with compost as compared with commercial fertilizers. If, however, we are to supply an adequate diet for man, we must have an abundant supply of fertilizers. To attempt to rely wholly on our limited supply of "organics" would prove disastrous even though further work might demonstrate some slight advantage from a nutritional point of view.

Investigations of the relationship between soils and nutrition have the important function of indicating how greater quantities of a better food supply can be provided for increasing world populations. During most of man's agrarian existence he has been able to grow his food on the best soils. With rapidly increasing populations that day is passing and he must learn to use soils of a lower fertility level. Basic information about the effect of soil characteristics on the nutritional quality of food should be obtained now in order that problems when they arise can be solved intelligently. Probably no critical situation exists at the present time. One could occur as demand for more food forces its production on less desirable soils.

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VACCENIC ACID AND SUMMER BUTTER

Evidence for the existence of a "summer butter factor" and its identity with vaccenic acid (Δ^{11}-octadecanoic acid) has been reviewed previously (*Nutrition Reviews* **6,** *104* (*1948*)). Three different laboratories have recently reported their inability to find any growth-promoting action of vaccenic acid in rats. Some of these investigators have also failed to demonstrate any growth-promoting action of summer butter when compared with other types of fat.

H. J. Deuel *et al.* (*J. Nutrition* **35,** *301* (*1948*)) have described experiments in which they could find no growth-promoting action of vaccenic acid. The vaccenic acid used in their work was extracted from partially hydrogenated China wood oil (a good source of this compound) and identified by appropriate chemical tests. Also, they fed hydrogenated China wood oil as such, again with negative results. H. Nath, V. H. Barki, C. A. Elvehjem, and E. B. Hart (*Ibid.* **36,** *761* (*1948*)) have reported similar results. The vaccenic acid used in their experiments was isolated from butterfat or commercial hydrogenated cottonseed oil (Crisco). They also used the *cis* and *trans* forms of synthetic vaccenic acid with negative results. Further negative results have been reported by B. von Euler, H. von Euler, and G. Lindeman (*Arkiv kemi, mineral. geol.* **26B,** *No. 3* (*1948*)) using vaccenic acid prepared from pure beta-oleostearic acid.

These reports would seem to establish that vaccenic acid has no growth-stimulating action in rats with the experimental conditions used. It is possible that the dietary conditions or materials used by J. Boer, B. C. P. Jansen, and A. Kentie (*J. Nutrition* **33,** *339* (*1947*)) in their original work may have been sufficiently different to permit them to demonstrate this effect. It should be noted however that subsequent investigators have used diets and conditions patterned after or similar to those used by the Dutch group as well as various other dietary modifications with equally negative results.

H. J. Deuel *et al.* (*J. Nutrition* **38,** *361* (*1949*)) thought it possible that Boer and associates (*loc. cit.*) may have been mistaken in the identification of their "summer butter factor" as vaccenic acid. Δ^{12}-Octadecanoic acid has some chemical properties very similar to vaccenic acid. Accordingly they carried out tests feeding *trans*-Δ^{12}-octadecanoic, a *cis-trans*-mixture of Δ^{12} and Δ^{11}-octadecanoic acids, as well as a 50-50 mixture of *trans*-Δ^{11} and Δ^{12}-octadecanoic acids. Again no growth stimulation was observed.

It is possible that the effects observed by Boer *et al.* may have been due to still other substances found in butter. However, there are reports which cast considerable doubt on the existence of a "summer butter factor."

Some investigators (B. von Euler, H. von Euler, and I. Säberg, *Die Ernährung* **8,** *257* (*1943*); B. von Euler and H. von Euler, *Arkiv kemi, mineral. geol.* **25B,** *No. 2* (*1948*)) have found no measurable growth-promoting action of summer butter. H. J. Deuel, E. Movitt, L. F. Hallman, and F. Mattson (*J. Nutrition* **27,** *107* (*1944*)) have obtained similar results. Deuel *et al.* (*loc. cit. 1948*) did find summer butter diets superior to diets containing rapeseed oil in confirmation of the results of Boer *et al.* (*loc. cit.*). However, they attributed this effect to the high content of erucic acid and the poor digestibility of the fat.

Vaccenic acid would not improve growth on the the rapeseed diets in their experiments. Nath *et al.* (*loc. cit.*) did find that butterfat promoted better growth than corn oil when lactose was the sole carbohydrate in the diet, but not when other carbohydrates were used, as previously reported by R. K. Boutwell, R. P. Geyer, C. A.

Elvehjem, and E. B. Hart (*J. Dairy Sci.* **26,** *429* (*1943*)). However, vaccenic acid did not appear to be concerned in this difference.

The question of the existence of a summer butter factor verges on the controversial question as to whether any type of butter is superior in growth-promoting action to good vegetable oils. This subject has been reviewed on numerous previous occasions and will not be discussed here (*Nutrition Reviews* **1,** *358* (*1943*); **2,** *165*, *267* (*1944*); **3,** *271* (*1945*); **4,** *140* (*1946*)). Whatever may be the final outcome with the conflicting reports on the nutritive value of butter, it appears that vaccenic acid has no growth-promoting action in rats. Whether any other substances in butter can be shown to have this property remains to be determined.

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